INCREASE emphasis on smart, energy efficient and sustainable building going forward

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Introduction: The annual increase for energy costs is going up by approximately 4% per year. With Global Warming getting national recognition, now more than ever, there will be a large push to lower environmental pollutants by utilizing smart energy consumption. Energy conservation and building sustainability is becoming a large topic in the Architectural and Engineering professions. I utilized contacts from the Society of American Military Engineers and did extensive research on the internet on this topic.

I spoke with an Engineer who worked for the federal government and was active in an Energy Conservation Program. They have multiple site locations throughout the US and started to monitor the energy consumption. The Program Office made it perfectly clear that the results were not consequential to the location managers' performance evaluation, the results would be published as to who spends the most money per square foot. As the results were posted monthly, the managers naturally started to become competitive to see who could get their energy consumption the lowest. In a five year period, this agency reduced its energy consumption by 27%, simply because energy consumption was something that was thought about on a regular basis. Together, they celebrated the savings as a team.

In speaking with OBO's Champions, the State Department was interested in learning more and getting some industry feedback on four technologies: Wind Turbines, Photovoltaic Cells, Magnetic Levitation Chillers and Ground Source Heat Pumps.

Wind Turbines – Is there anything smaller?

One DOD Agency has a (4) 275-foot tall wind turbine with blades spanning 177 feet each, which generate 950 kilowatts (kW) of electricity. Together, the four turbines will generate 3,800 kW, and in years of typical weather the wind turbines will produce almost 8 million kilowatt-hours of electricity. They will reduce the consumption of 650,000 gallons of diesel fuel, reduce air pollution by 26 tons of sulfur dioxide and 15 tons of nitrous oxide, and reduce greenhouse gas emissions by 13 million pounds each year. This resource will provide as much as 25% of the base's power generation during the high-wind months of late summer, and are expected to save taxpayers $1.2 million in annual energy costs. The project cost is nearly $12 million.

Since the State Department is working with limited land, structures of this size are not ideal; therefore I tried to find other technologies utilizing wind as an energy source.

Offshore wind turbines – these can be less obtrusive than turbines on land, as their apparent size and noise can be mitigated by distance. Because water has less surface roughness than land, the average wind speed is usually higher over open water. This allows offshore turbines to use shorter towers, making them less visible. In stormy areas with extended shallow continental shelves (such as Denmark), turbines are practical to install, and give good service — Denmark's wind generation provides about 25-30% of total electricity demand in the country, with many offshore wind farms. Denmark plans to increase wind energy's contribution to as much as half of its electrical supply.

Airborne wind turbine - An airborne wind turbine is a design concept for a wind turbine that is supported in the air without a tower. A tether would be used to transmit energy to the ground. These systems would have the advantage of tapping an almost constant wind and doing so without a set of slip rings or yaw mechanism, without the expense of tower construction. The main disadvantage is that kites and 'helicopters' come down when there is insufficient wind. These schemes require a very long power cable and an aircraft exclusion zone. As of 2006, no commercial airborne wind turbines are in regular operation. (Wikipedia)

Photovoltaic Cells – Can they be less expensive?

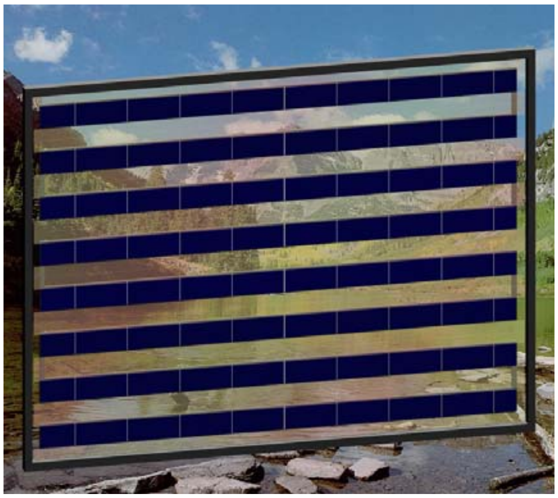
HoloSun Technology - The current ROI for PV Cells is about 20 Years – there is a new technology called HoloSun which is used with Building Integrated Photovoltaic (BIPV) – It is a thin film which covers existing BIPV structures and increases the energy output by 25-40%. To get the same amount of energy output, the amount of PV cells needed to be purchased can be reduced significantly. The initial cost of installation comes down by 2/3 and the ROI timeframe is decreased by more than 50%. This new type of PV uses holographic technology as well as less expensive materials as opposed to lenses and mirrors, therefore the cost of the materials is much less and is less expensive to run ($2.00/watt Peak vs. $3-5.00/watt Peak). The product can be used on roof tiles or any part of the building structure where there are BIPV Cells located.

Statistics on the potential savings at the Geneva Embassy assuming the costs of Kwh were the same and same amount of BIPV were used:

Embassies using BIPV w/ SunPhocus	Geneva	25% Savings had this been used	50% Savings had this been used
PV KW/H	270	337.5	405
Dollars in Savings	$60,000.00	$75,000.00	$90,000.00
Carbon Emissions Reduced	150,000 lbs	187,500 lbs	225,000 lbs

Paradigm Shift with Building Integrated Photovoltaic (BIPV)

Semi-transparent Solar Windows



Generate Electricity from Building structure

PV Hologram-Concentrator

PV hologram-concentrator Module

Semi-transparent Holographic Concentrator between Two Layers of Glass*

PV Cells

Conventional PV Module**

PV Cells

- Better Solar power windows for building applications
- Takes sunlight and concentrates it into photovoltaic ("PV") cells which, in turn, converts sunlight into electricity.
- Provides 20-40% increase in power output per unit area of PV
- Allows the use of fewer PV cells per window

Magnetic Levitation Chillers – What is the average ROI?

Another Federal Agency is using Maglev Chillers. This technology is extremely efficient and increases lifecycle and maintenance costs compared to ordinary chillers. Approximately 30-40% of energy consumption is spent on cooling buildings. This technology can save approximately 35% of the costs associated with energy consumption.

I also spoke with a building engineer who oversees (2) 11-story buildings where it was mainly used as a University classroom. They have a 400 ton Maglev Chiller and have been monitoring the savings closely. Since the original installation, they have installed a **Control Plant Enhancement** which allows true compressor utilization and optimization of load capacity, which saved more energy. For example, they have an exact read on the compressor RPM's so he knows when to start up an additional compressor. Evenly distributing the load can significantly save energy. The average cost of a Kwh in his location was 15 cents/kwh and have seen a 42% decrease in electrical costs.

Although Maglev Chillers are about 20% more expensive, the lifecycle costs and maintenance cost are significantly lower. Current chillers must have oil analysis completed once per year at $2500 average. Every five years they recommend the compressors be rebuilt which costs $30,000. Since the Maglev Chillers don't use oil and don't have the friction which would case the compressor to be rebuilt, there is a total savings of $210,000 over the 25 year lifecycle. $150K for rebuilds and $62,500 for oil analysis. This also doesn't include the labor costs for performing the maintenance.
The Maglev Chiller must have its capacitors changed every 5 years at $500 in parts. $2500 over a 25 year lifecycle. This, again, does not include labor.

Maintenance of the Average Oil Chiller	Cost per cycle	Lifecycle Cost at 25 years
Oil Analysis	$ 2,500.00	$ 62,500.00
Compress re-build	$ 30,000.00	$ 150,000.00
Total	$ 32,500.00	$ 212,500.00
Maintenance of Maglev Chiller	Cost per Cycle	Lifecycle Cost at 25 years
Replace Capacitors	$ 500.00	$ 2,500.00
Total Savings	**$210,000.00**	

Statistics on the average embassy based on 10 locations:

Post	kwh/yr	Average of 35% of energy used on cooling	Kwh/year With MagLev Savings of 35%	Cost/Kwh	$ Savings
Biskek	1050759	367766	128718	$0.018	$ 2,316.92
Dar se Salaam	3493329	1222665	427933	$0.066	$ 28,243.56
Doha	2341653	819579	286852	$0.020	$ 5,737.05
Kampala	1661290	581452	203508	$0.082	$ 16,687.66
Lima	5443755	1905314	666860	$0.063	$ 42,012.18
Moscow	15985100	5594785	1958175	$0.039	$ 76,368.82
Nairobi	2863440	1002204	350771	$0.066	$ 23,150.91
Ottawa	3061030	1071361	374976	$0.067	$ 25,123.40
Tunis	3261582	1141554	399544	$0.061	$ 24,372.17
Zagreb	2171160	759906	265967	$0.061	$ 16,223.99
Totals	**41,333,098 kW**	**14,466,584 kW**	**5,063,305 kW**		**$ 260,236.67**

Ground Source Heat Pumps – What is the ROI and is there a less expensive alternative?

I read several case studies of GSHP installations which took place on school, government and commercial facilities. The ROI varied from case to case with very little consistency. One common feedback was that the amount of O&M time was reduced and there was a significant energy savings, as well as an environmental benefit. Some highlights of a few case studies were as follows:

- School Systems
  - $240,000 system which returned $40,000 per year in savings – a six year return on investment.
  - A school system installed a total of four systems (3 retrofit, 1 new install) and they are averaging approximately a 25% per school regardless of school size, school features, and the type of previous system.
  - Another school system had a 12 year ROI to retrofit a new system but was happy with the systems ability to lower its O&M costs, lower energy bills, decreased the size of the room needed to house the heating system. The costs of the systems to install in a new building would have been 4% more expensive.
- Government
  - An $18,000,000 system installed on a military base to convert the heating and cooling systems of approximately 4,000 military family housing units. This privately funded investment is paying back at $3,300,000. Roughly a 5.5 year ROI. Because this project was privately funded, the government

    was only able to keep 22.5% of the savings, which equates to $750,000/year.
  - Another military installation which replaced their natural gas heating and cooling systems of 236 living units with GSHP and is saving approximately 36%/year. They are measuring the ROI by keeping 2 units running on furnace, water heater, gas stove and electric air conditioner and comparing the costs to "smart" houses using GSHP, thermal improvements, lighting retrofits, and new refrigerators.
- Commercial
  - One case study which I read showed the largest commercial GSHP projects recorded to date. It was for a hotel complex which was 750,000 square feet. The ease of maintenance and environmental benefits were the main benefits. The total energy savings for this massive complex is $272,000 a year with a savings of 5.6M KWh a year. They also saved approximately 25,000 square feet of space where conventional equipment would have been.
  - A GSHP installed at a ski resort in Canada was my best case study for a cold environment, where temperature drop to as low as minus 40 degrees Fahrenheit. To install the GSHP as opposed to the conventional alternatives was 20% more and the ROI was just a few years with an amazing operating cost of just 25% of what the costs would have been through conventional heating.

Other energy conserving ideas/technologies:

Creating "Hybrid Systems" - Wind and solar are often combined in a hybrid system because they reinforce each other on a daily and seasonal basis. The wind often blows when the sun is not shining (night, storms, winter, etc.). The sun often shines during periods with low wind (summer, wind lulls due to high pressure systems, etc.). – (Bergey WindPower – www.bergey.com)

Self Cooling Microchips – Ion Pump Silicon for IT Server Rooms – 50% of energy costs can come from IT servers and equipment. Keeping the equipment cool can take up a lot of space and energy. This new technology will be out in the next few years.

Sustainable SMART and High Performance Facilities–The business case for the customer is maximized when a systems integrator is brought into the early stages of architecture and engineering (A/E) to create a working relationship with the end-user to identify, design, and engineer the IT infrastructure for a facility. In so doing, the optimal use of technology is used to advance the customers' mission objectives. In this manner, technology will drive the A/E phase of the facility life-cycle and help to shape the customer's future operational environment which inevitably extends building life-cycles and lowers O&M costs.